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ABSTRACT

The focus of this workshop involving people from 13 countries in Asia and the Pacific Region was on using computers to assist learning in mathematics. The report contains the following sections: (1) Introduction; (2) The Mathematics Curriculum: Innovation and Change; (3) The Mathematics Classroom: New Ideas with Computers; (4) Software: Quality and Development; (5) The Teacher: Development and Support; (6) Other Issues; (7) Summary and Recommendations; (8) Appendix 1: List of Participants; (9) Appendix 2: Country Report Summaries (Australia, Bangladesh, China, India, Indonesia, Japan, Malaysia, New Zealand, Pakistan, Philippines, Republic of Korea, Sri Lanka, and Thailand); and (10) Appendix 3: List of Some Computing Terms. (RH)

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SCHOOL MATHEMATICS:

New Ideas with Computers

SE 049 676

N I E R

School Mathematics:

New Ideas with Computers

Section for Educational Co-operation in Asia
National Institute for Educational Research (NIER)
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Chapter 1: Introduction

1. *Background*

This monograph is an outcome of the deliberations of participants in ***the Regional Training Workshop on School Mathematics and Microcomputers in Asia and the Pacific.*** The Workshop, convened by the National Institute for Educational Research (NIER) of Japan in collaboration with Unesco was held in Tokyo *from 23 June to 13 July 1987.* Sixteen participants from 13 countries in Asia and the Pacific region attended. In addition, three resource persons were invited and Unesco was represented by two programme specialists. Four observers also attended sessions. The list of participants including the names of officers elected is given in Appendix 1.

The terms of reference for the Workshop related specifically to mathematics education and computers, particularly:

* an exchange of experiences;
* enhancing the existing curriculum;
* exploring new curriculum areas;
* issues involving software; and
* strategies for future plans associated with mathematics, computers and teacher training.

The focus of this monograph is on using computers to assist learning in mathematics and not on learning how to use or to programme computers.

2. *Why use Computers?*

Computers have changed what mathematics is used in the world and how this mathematics is used. Mathematicians and scientists now use computers as a basic tool. Considered out of the reach of ordinary people only a few years ago, computers have infiltrated every segment of society - from communications to cooking, finance and farming, aeronautics to education. With calculators and computers, the difference between the way mathematics was taught in schools and its actual use in life is apparent.

The processes of mathematics are becoming as important as the knowledge of its content. Schools operate in the world of today but are educating students who will be the adults of tomorrow. It is important that mathematics education for these students reflects, as much as possible, the use of computers in society, as well as promoting a flexible attitude to respond to further changes.

In addition to the changes in mathematics and its uses, it is believed that mathematics can be taught more effectively with computers.

As technological advances become available, it is normal to consider their uses. In education, changes ranged from slates to paper; from quills to pens, pencils and ball-points; from blackboards to white boards and overhead

projectors; from pictures to film-strips, films and videos. In mathematics, many countries now use calculators to supplement the mental and paper and pencil calculations that are done. The most recent and far reaching advance in technology is the introduction of computers, and educators are considering how these will influence learning and teaching.

The way that all technology is quickly put to use in education suggests that the question, "Why use computers?", is irrelevant in some countries. The more relevant question would be, "How (best) can computers assist learning?". For some countries, however, consideration of computers would be in terms of the computers' power to do many things accurately and speedily. This powerful tool could change our way of working in general and in using mathematics in particular.

3. *The Present Situation*

Most educational systems have introduced computers, formally or informally, into some schools or are considering the introduction of computers into schools. The range of experience varies between countries and covers such diverse activities as the use of computers

for computer awareness courses;
for computer studies courses;
for school administration;
in teaching one or two subjects (including mathematics);
in teaching most curriculum areas;
for activities outside of formal classes.

Mathematics has a unique link with computing because of the historical relationship during the development of computing. Some mathematics teachers studied some computer science during their training at university and many of the initial uses of computing were related to mathematics. The link between computing and mathematics can also be viewed as an extension of the mathematics-calculator link. In this context, mathematics has already started to move away from its earlier emphasis on arithmetic and algebraic manipulative skills. This movement has been intensified as computers now offer the use of real problem solving packages, spreadsheets, databases and graphing packages.

The availability of computers varies from country to country. Mathematics classes in some countries have no access to computers, and in others, each mathematics class has access to a considerable number of machines. Curriculum developers in mathematics are now asking questions like, "Are the (mathematical) skills and competencies needed by our graduating students changing because of the use of computers in society?". Where some computers are available, teachers and curriculum developers are asking "What is the best way to use this resource to improve the learning (of mathematics)?".

4. *Future Trends*

It is likely that the cost of computers will continue to fall; the range of uses for computers will continue to grow, and greater numbers of students

will have access to computers at home and in school. When the price and size of a solar-powered computer is similar to the price and size of a textbook, the influence on the mathematics curriculum will be inescapable.

Similarly, software will become more easily available, more sophisticated and more user-friendly; and most students will not need a knowledge of programming.

While these changes are occurring, the curriculum will need to be revised or modified to reflect the changing applications and uses of mathematics in a computer society. Teaching methods will need to change to accommodate the use of computers. The extended use of the computer in mathematics will empower students to take more responsibility for their own learning. This will be manifested through the use of high quality software that promotes individual and group problem solving. In this way, students select problems from a range of activities and open-ended investigations. This will change the teacher-student relationship and the attitudes that students bring to their learning and teachers bring to their teaching.

While these changes reflect a change in the role of teachers, they do not diminish the teacher's importance in the mathematics classroom.

In the near future, computers will be readily available. It will not be the case of enhancing mathematics education by using computers but that a new mathematics education will evolve.

Chapter 2: The Mathematics Curriculum: Innovation and Change

Education aims to provide opportunities to develop individuals for effective participation in day-to-day life, and prepares them for further education and work, so that they can make a worthwhile contribution to society at large. The mathematics curriculum contributes by cultivating the skills of numeracy, rational and creative thinking and problem solving, together with reinforcing the general skills of observation, generalization, communication, using tools and social interaction.

As computers are becoming an important part of society (which is fast transforming into a technological society), exposure to them and training in their use needs to become part of every subject. In classrooms, the computer can be used as a powerful tool to facilitate students learning mathematics and teachers teaching it more effectively.

The computer has a number of capabilities that existing aids do not have. They are:

1) Animation and colourful display;
2) Storage and retrieval facilities for large quantities of data;
3) Speedy and accurate computation and manipulation;
4) Repetition;
5) Simulation;
6) Speedy and accurate figure and graph drawing;
7) Instantaneous feedback;
8) Control over speed of presentation; and
9) Provision for individualized instruction.

These capabilities affect the way that mathematics is taught and learned and the mathematics curriculum itself. These changes are explored in the following sections.

1. Learning that can be Enhanced with theUuse of the Computer

The teaching and learning of most of the topics and processes in mathematics curriculum can be enhanced with the use of computer if suitable software is prepared and used. Good software is costly and time-consuming to develop. In some countries, computers are not available to all pupils or are not available in sufficient numbers. Therefore, efforts need to be focussed on areas which the 'traditional' materials and methods cannot easily or effectively handle.

Table 2.1 lists the topics and the key processes that are usually found in the mathematics curriculum for schools at all levels. In addition, the specific capabilities of the computer in enhancing the teaching and learning of certain topics and processes are also integrated in the table.

Table 2.1: The Teaching and Learning that can be Enhanced with the Use of the Computer

Processes	Topics that can be enhanced	Computer capabilities employed
Calculating	All topics involving lengthy calculations	2 3 4 7 8 9
Algorithmic thinking	Operations (+, -, x, ÷)	3 4 6 7 8 9
	Ratio, Proportion, Percentage	3 4 7 8 9
	Elementary Number Theory (LCM, HCF)	3 4 7 8 9
	Transformations	1 5 7 8 9
	Equations and Inequalities	3 4 7 8 9
	Approximation and Estimation	2 3 7 8 9
	Matrices	3 7 8 9
	Sequences and Series	1 3 7 8 9
	Trigonometry	1 6 7 8 9
	Derivatives and Integration	3 4 7 8 9
	Probability Distributions	1 2 3 4 7 8 9
Establishing Relationships	Measurement (time, length, area, volume)	1 5 7 8 9
	Analytic Geometry (conics)	6 7 8 9
	Transformations	1 5 7 8 9
	Functions	1 5 6 7 8 9
	Equations and Inequations	1 6 7 8 9
	Real and Complex Numbers	5 6 7 8 9
	Sequence and Series	1 3 7 8 9
	Trigonometry	1 6 7 8 9
	Limits and Continuity	3 4 6 7 8 9
	Derivatives and Integration	1 6 7 8 9
	Probability Distributions	2 3 6 7 8 9
Generalizing	Angles and Shapes (2-D)	1 6 7 8 9
	Shapes (3-D)	5 7 8 9
	Transformations	1 5 7 8 9
	Sequence and Series	1 3 7 8 9
	Bar Charts and Histogram	1 2 3 6 7 8 9
	Measures of Central Tendency	2 3 6 7 8 9
	Probability Distributions	2 3 5 6 7 8 9
Providing with Deduction and Induction	Proof	1 6 7 8 9
Analyzing and Synthesizing	Proof	2 7 8 9

Table 2.1: The Teaching and Learning that can be Enhanced with the Use of the Computer (continued)

Processes	Topics that can be enhanced	Computer capabilities employed
Applying Concepts and Methods to Real Life Situations	Operations (+,-,×,÷)	5 7 8 9
	Ratio, Proportion, Percentage	5 7 8 9
	Measurement (Mass, Length, Area, Volume)	5 7 8 9
	Elementary Number Theory (LCM, HCF)	5 7 8 9
	Functions	5 6 7 8 9
	Equations and Inequalities	5 6 7 8 9
	Approximation and Estimation	1 5 7 8 9
	Matrices	3 5 6 7 8 9
	Sequences and Series	3 5 7 8 9
	Trigonometry	5 6 7 8 9
	Limits and Continuity	5 6 7 8 9
	Derivatives and Integration	5 6 7 8 9
	Bar Charts and Histograms	1 2 3 6 7 8 9
	Measures of Central Tendency	2 3 5 7 8 9
	Probability Distributions	1 5 7 8 9

Legend:
1: Animation and colourful display
2: Storage and retrieval facilities for large quantities of data
3: Speedy and accurate computation and manipulation
4: Repetition
5: Simulation
6: Speedy and accurate figure and graph drawing
7: Instantaneous feedback
8: Control over speed of presentation
9: Provision for individualized instruction

Table 2.1 reflects the knowledge of the participants, software available at the Workshop, and the present major uses of software within the region at the time of the Workshop. With the dissemination of new software and changes in computer capabilities, the table would need to be reviewed.

2. *Topics and Processes that can be Considered for De-emphasis*

With the enhancement of teaching and learning of some topics and processes, computers make drill and practice of certain skills unnecessary. For example, although it is essential that students understand the concept of division (÷) and are able to perform the operation, they do not need to do numerous exercises with large numbers, as these can be done speedily and accurately by a calculator or a computer. Some topics and skills (listed below) can be de-emphasized because of the use of computers. This does not necessarily imply that the topics or skills themselves should be deleted from the curriculum, but that the method of learning and practising them may be changed, and the time spent on them should be reduced.

* long mechanical calculations (numerical and logarithmic) and four-figure mathematical tables

* rational and irrational number arithmetic (including manipulation of fractions, prime factors, highest common factor (HCF), least common multiple (LCM), indices and surds)
* non-decimal angle measures (minutes and seconds of degrees)
* mechanical calculations and manipulations for solving equations, trigonometry, coordinate geometry, calculus, vectors and matrices, and statistics.

3. Topics and Processes that Need to be Emphasized

The capabilities of computers lend themselves better to teaching certain topics and processes, and these and other complementary processes may need to be emphasized. For example, as the computer can perform speedy and accurate computations, it is necessary for the student to have an idea of the magnitude of the result, so that errors in entry of data resulting in wrong answers may be detected. This can occur only if the student has an ability to make approximations and estimate results. Some of the topics and processes that need to be emphasized are:

* making and reading tables
* measuring, reading scales and calculating with precision and accuracy
* approximating and estimating
* understanding (and use) of algorithms
* formulating of equations and problem-solving using graphs, functions
* analyzing statistical data
* understanding and applying basic principles in trigonometry, coordinate geometry, calculus, vectors and matrices
* modelling (e.g. mechanics and linear programming)
* using discrete mathematics (e.g. permutations and combinations)
* investigating, hypothesizing and problem-solving.

4. Issues

The changes in the teaching and learning of mathematics with the help of computers and the changing emphasis on certain topics and processes implies that the mathematics curriculum needs to be reviewed. The sequencing of, and the balance within, the topics, processes and skills in many present curricula need to be reconsidered so that a suitable progression occurs. Emphasis of some, and de-emphasis of other topics and processes has to be done in such a way that the curriculum does not become too full.

The use of computers has implications for the writing of textbooks, teachers' guides and resource materials. While it may not be possible for all countries to provide computers in all schools, mathematics teachers who have computers in their schools need access to information and guides about the uses of computers in mathematics.

When mathematics is assessed by external examination, the work done with computers needs to be prescribed so that more study with computers will be done.

Chapter 3: The Mathematics Classroom: New Ideas with Computers

This chapter is about computers in the mathematics classroom and supplements the last chapter's considerations of curriculum issues. It focusses on the role of computers in the mathematics classroom as a means of enhancing the learning and teaching of mathematics.

1. What Students Experience

Students learn mathematics through a variety of experiences. These can be considered in a number of different frameworks.

a) Expository Teaching and Discovery Learning

Exposition has been the usual method by which mathematics has been taught for many years. It usually follows the sequence of

* presentation of information by teacher exposition;
* drill and practice;
* testing of reception, recall and understanding; and
* application.

Computers can assist in each of these areas by; simulation software as an alternative to teacher presentation of information; drill and practice software to test and assess student answers and to provide further drill; and specific open-ended software which allows the student and class in general to apply any knowledge or skills gained.

Discovery learning is being more widely used within the region. The major points within it are

* presentation of opportunities for learning;
* testing of an understanding of the cause-effect relationship;
* testing for the formation of the general principle; and
* applications of knowledge gained and its understanding.

Several software systems have been developed to assist the discovery approach, for example, LOGO, Geometric Supposer and Algebraic Supposer. Generic software such as graph plotters can also be used for exploration and for verifying principles. Numerous open ended packages give opportunities for applying the knowledge gained and understanding.

b) Concrete, Semi-concrete, and Abstract Activities

Mathematics is usually taught using all three of these, and the balance depends on the age and level of the school students, the overall teaching approach, the content, the available resources and needs of the syllabus.

Concrete activities relate to handling actual physical materials and the computer does not usually offer this facility. Semi-concrete activities involve manipulation of representations of concrete materials or pictures of

them. The computer assist this by using displays of static or animated visual data on the screen. Abstract activities involve representing ideas in a general form with words as concise symbols and these can be manipulated easily by computers.

c) Oral, Visual, Written and Practical Work

Learning activities should incorporate work of these four types. Aspects of oral work involving student discussion have been a weakness in mathematics. The computer with appropriate software provides opportunities for students to talk to each other and the teacher. It is often desirable to encourage work in small groups with computers and this encourages learning from each other, and raises the level of interaction between students.

When a computer is used for display and to stimulate discussion, interaction between the students, and with teacher is encouraged.

A method for providing visual work uses the computer's ability to present animated and static displays in a range of colours. Control of such displays cannot be easily managed with other equipment, as only linear sequencing is available with media such as film or videotape.

Students can also use various mathematical tools such as graph plotters which display families of graphs using visual images. Similarly, other software tools allow the manipulation of visual images which are semi-concrete examples, such as the representation of a LOGO turtle's operation on a screen, reflecting the actions of a device (or student acting as a turtle) on the classroom floor.

Written work can be supported with the computer's abilities to manipulate words and symbols on its screen, and as a means of preparing or presenting materials using word processors. Students can use computers within the classroom to prepare their responses to particular tasks which have resulted from individual or group work.

Practical work which involves concrete material usually supplements computing activities. However, computers can be used to monitor experiments and to record and process results.

No matter which framework above is used to consider learning experiences, computers can assist. They possess unique attributes, such as patience, speed of computation, and the ability to present information in different forms which may be more useful than other methods.

2. *What Teachers Do*

A discussion of what teachers do in the classroom should focus on how the teacher approaches teaching: whole class, groups, or individualized teaching. It should also reflect the ways in which mathematics is taught, with choices between structured and unstructured lessons and between using inductive and deductive reasoning.

Teachers use a variety of groupings within the classroom, sometimes the whole class, sometimes small or large groups, and sometimes individuals for part or all of the time. In each case, computer programs may offer assistance:

* to individuals in:
  - drill and practice;
  - tutorials for remedial instruction; and
  - exploration for the extension of talented students.

* to small groups in:
  - drill and practice;
  - tutorials; and
  - explorations.

* to large groups or the whole class in:
  - demonstration; and
  - interactive software and other materials which test and refine hypotheses derived from them.

Much software provides assistance for more than one type of activity; for example, a piece of software which simulates the flight of an aeroplane. A tutorial part of the software would provide an example for the user to follow. This software allows the user to control the plane's up, down, right and left movements using the keyboard. The simulation asks the user to navigate through a particular airspace.

In terms of the styles of teaching, some teachers prefer a very structured programme, and will follow a well-defined path of presentation; others prefer a less structured method of teaching, with the route to the endpoints being much less well-defined and the endpoints not necessarily as fixed. Computers may support each style and follow either approach. Through careful choice of software, teachers can retain control over their style, and can use the computer to support their preference.

Mathematics uses deductive and inductive reasoning. Each has a part to play in the education of the student. Teachers often use deductive processes which start from general examples and move to particular ones, while inductive processes start with particular examples and move to general ones.

In both cases, computers can help because of their ability to present examples to the student in a controlled sequence, and to offer computational power which makes the verification of inductive and deductive hypotheses much easier. There are many open-ended packages which allow the use of both inductive and deductive teaching styles.

An example of this would be LOGO, where the students can be lead inductively to think of a general procedure for enabling the turtle to draw a many-sided regular polygon, based on previous procedures for drawing a triangle, a square, a pentagon and so forth.

3. *The Computer-Student Ratio*

Available resources in terms of hardware and software may determine the way computers are used in the classroom.

a) One Machine per Class

If only one machine per class is available, the computer can be used for demonstration, simulation, drill and practice as well as to test hypotheses derived from the whole class. This use can be improved by structuring the whole class into groups, and having individual groups work on the computer, while the remaining students are involved in other activities. This use does have advantages, as it encourages all students to participate in the formation of hypotheses such as testing various ideas in LOGO, or responding to questions which may later be answered using the computer at some stage. If the teacher uses 'whole-class work', then this usage can be improved by using a large screen, a number of monitor screens or linking the screen with an overhead projector.

The 'small group within a class' structure deserves mention, as it places extra responsibility on the teacher to ensure that work is maintained while groups are going through various activities. It is an activity that can be most rewarding for large number of students when only limited resources are available.

b) One Machine per Group

One machine per group implies that there may be several machines in the classroom or computer laboratory or that group teaching is being used. The use of computers can reflect a teaching strategy that relies on interaction between members of each group. Some educators have found that this leads to interesting group dynamics and the teachers should monitor the groups to ensure that all students are contributing to the best of their ability. This group interaction can contribute positively to the formation of mathematical concepts by individuals.

c) One Machine per One or Two Students

One machine per one or two students may imply whole class, group, or individualized learning. With individualized learning the teacher must take greater care to ensure that work is being carried out and that students are progressing at their speed. While it may allow maximum individual development by student and offer advantages in the way the class is organized, learning theory suggests that group work, with small groups of two or more students, has positive advantages for the formation of concepts.

4. *Optimum Number of Computers*

There should be one or more computers for use in every mathematics classroom, or at least each mathematics class should have access to a computer. Each country, within its own policies and resources, should realize that a ratio of one computer per two or three students may be a realistic optimum and may lead to most effective learning in a mathematics classroom.

Where whole class teaching is less common, a smaller number of computers can be used for a broad range of activities. Research needs to be done to find the ideal number of computers in each country's own cultural setting.

Chapter 4: Software: Quality and Development

There are now many mathematics software packages available. It is important that teachers are able to find out about them, and use them in the classroom. Teachers must also be in a position to assess if they are useful. Software is 'good' when the package provides a close match between the subject matter to be covered, and the teaching and learning styles within the class. For the purposes of this monograph, the term 'software' implies the disk and the documentation. If the phrase 'software package' is used, the student and teacher notes are also included. In some countries, this is referred to as 'courseware'.

1. *What Makes Software Useful*

The usefulness of a software package will depend on its effectiveness at an individual classroom level, and within an education system. It must be easy for both students and teachers to use. The existence of teacher notes with the software is desirable. Student workbooks should be available if the software needs them. The cost of a package can influence its use, through discouraging its initial purchase or its extended use through the lack of provision for multiple copies.

2. *Software for Mathematics*

Many software packages are now written for the mathematics classroom. Some countries have reviews of software on print and electronic databases which teachers can use to identify appropriate packages for their own use. The categorization of software in those databases is helpful to describe the software itself and its use. This categorization also helps in identifying areas where software does not exist or is not being used effectively.

Types of mathematics software that were available at the Workshop or within the region have been classified according to who, or which organization originated the software and whether its major use would be in primary or secondary schools. This information is reproduced as Table 4.1. The list is not exhaustive, and a blank entry does not imply that no software is available.

Table 4.1: Classification of Mathematics Software by Type and Origin

Use / Origin	Teacher		Educational System		Commercial	
	Primary	Secondary	Primary	Secondary	Primary	Secondary
Drill and Practice	Arithmetic Measurement	Arithmetic Algebra	Arithmetic Geometry Measurement	Arithmetic Algebra Geometry	Arithmetic Geometry Measurement	Arithmetic Algebra Geometry

Table 4.1: Classification of Mathematics Software by Type and Origin (continued)

Use / Origin	Teacher		Educational System		Commercial	
Demonstration	Arithmetic	Algebra Geometry Trigonometry Calculus	Arithmetic Algebra Geometry	Algebra Geometry Trigonometry		
Simulation		Probability		Probability Algebra Geometry		Probability Algebra Geometry Statistics
Exploration	Arithmetic	Algebra Geometry Trigonometry	Arithmetic Measurement	Algebra Trigonometry	Arithmetic Measurement	Geometry Algebra
Tutorial		Arithmetic Algebra	Algebra		Arithmetic	Algebra

3. *Content Free (or Generic) Software*

There is software which is used as a tool and which has no initial data, or implied content. This software is sometimes called 'content free' or 'generic' and includes word processors, databases, spreadsheets and other packages which leave the mode of use and determination of content to the user.

Teachers should not ignore the opportunities that can be created by the use of such software in the classroom. The use of databases may reinforce the operations involved in set theory, as well as providing student interest in the creation of their own data resources. Spreadsheets provide a means for streamlining calculations, especially in the areas of vectors, matrices, statistics, and in any area of mathematics where algorithmic thinking is employed. Teaching the use of spreadsheets may be an alternative to teaching a formal programming language.

4. *Areas for Software Development*

Areas where software is non-existent, or very limited in extent, must be established and enunciated with reference to curriculum requirements, and to teaching and learning strategies. Individual countries do this for themselves and it may be appropriate as a diagnostic mechanism to create a grid listing curriculum topics on one axis, and either teaching and learning strategies or software styles on the other.

The software needs can then be assessed to find if:

* the software already exists in some other countries. In this case, negotiations will need to take place for purchase, license or adaptation.

* the software exists and is available in the country but has insufficient support material for effective use. In this case, support material may need to be developed.

* the software does not exist and should be developed. In this case, the available mechanisms need to be used for the development of both software and support materials. This case is discussed in detail in the next section.

a) Software Needed

This Workshop considered that there was an urgent need to develop software with support materials in the areas listed below. An indication of the most appropriate teaching and learning style for the software is also given:

* LOGIC AND PROOF (problem solving)
* 3-D GEOMETRY (concept development)
* CALCULUS (concept development, and drill and practice)
* TRIGONOMETRY (concept development)
* ALGEBRA (concept development and problem solving)
* INTEGRATED STATISTICS PACKAGE

b) Support Materials Needed

This Workshop also identified areas where software presently exists but with insufficient support materials to encourage effective implementation in the classroom. These areas are:

* DESCRIPTIVE STATISTICS
* GEOMETRY (2-D)
* GRAPH PLOTTING
* SPREADSHEETS

5. *Development Strategies*

Many individuals and organizations are developing software. Individual teachers with programming knowledge develop software in their schools and then distribute it to other teachers, either free of charge (individually or through central coordination), or joining with other teachers with similar skills to form small companies to market their software.

Existing commercial groups, who already market educational books and materials, offer a range of software products. These are usually well developed, trialled and supported, but may be provided at a high price for schools.

Many education authorities and specialist institutions are also now developing software. The software produced by this method is usually created with teacher and other specialist assistance, and the final product disseminated in an efficient manner to schools. Knowledge about the software and use of the software outside the authoring country is very limited.

* Suggested Strategies for Development

There are many models of software development being adopted and used. However, the model described in the Australian publication 'A Guide to the Design and Development of Educational Software'[1] was typical, and is reproduced below.

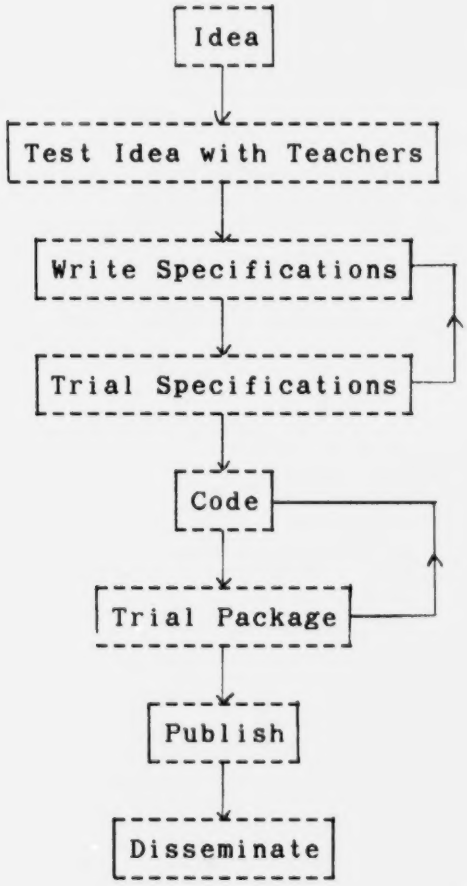

Figure 4.1: Model for Software Development

Educational authorities and agencies realize that teachers are the best source of ideas for teaching materials. Students can also produce software that can be used in the classroom, but they may lack the perspective of the whole curriculum, or the pedagogical knowledge required to create an integrated package. The above model uses the generation of ideas by a single teacher or by groups of teachers.

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1. Commonwealth Schools Commission, A Guide to the Design and Development of Educational Software, 1985.

This model may be used in workshops organized by groups of schools, regional authorities, in-service agencies or tertiary institutions. The ideas are then tested with other teachers. The development team may be supplemented by subject specialists, pedagogic experts and persons knowledgeable about the type of computer for which the software is planned. The team designs the software specifications. The education authority may then contract or arrange for coding of the specifications, trialling and review of the software before its publication and distribution.

The strengths of such a model are that the software is relevant to the curriculum, pedagogically sound, and publication and distribution is accomplished. The disadvantage is that the time scale is often long.

Commercial enterprises often adopt a similar model for development involving practising teachers, or former teachers to generate and develop ideas. The market audience is usually clearly defined and the software is often tied to other resource material that the company produces. The disadvantages are that the product is often highly priced and addresses only those parts of the curriculum for which there is an expected financial return.

Some countries are now trying a model for software development that links the education system with commercial enterprises. The advantages of this model are that teachers and education systems are involved in the generation and development of the ideas and specifications, and commercial enterprises are involved with the production of the software and associated material and its marketing. The education system is seen as investing the talents of its teachers and their salaries while they are involved. The commercial enterprise commits resources and money into publication with an expected financial return. The price of the software is usually negotiated between the joint partners.

6. *Evaluation of Software*

Several forms of evaluation occur.

* Evaluation of software packages by individual teachers for their own purposes.

* Evaluation of software packages by 'experienced' resource persons. This evaluation may use prescribed criteria contained in a check list or a review sheet. An example of this type of review sheet is given on the next page. (It is the standard format used by the Queensland Education Department, Australia.)

* Evaluation of software over a period of years is undertaken. Such evaluation is important as it provides answers to questions such as "Which is the best strategy employed in using spreadsheets to teach concepts in problem solving?"

An SCS Production

SCHOOLS COMPUTING SERVICES
DEPARTMENT OF EDUCATION QUEENSLAND
Ph. 224 6284

COMPUTER SOFTWARE REPORT

REF. NO. M85

GENERAL INFORMATION

Program title/s: Gears
Publisher: Sunburst Communications
Year of publication: 1985 **Approximate price:** $79.95
Review copy supplied by: Pencom, Ramware
Available for: Apple II+, IIe, IIc; IBM PC/PC jr; Tandy 1000; Tandy CoCo
Reviewed on: Apple IIe **Storage:** Disk
Peripherals required: Disk drive

CURRICULUM MATCH

Year level: 6-12
Unit title / Topic area: Problem Solving, Division of decimals & whole numbers
Subject/s: Mathematics

PROGRAM DESCRIPTION

Drill		Educational game		Word processor	
Testing		Prepared database		Utility	
Simulation	X	Programming language		Spreadsheet	
Tutorial		Programming utility		Database management	
Problem solving	X	Electronic blackboard		(Other)_____	

General description:

The program promotes problem solving skills by allowing the user to experiment with the properties of gears. Gears with 5, 7, 9, 11 or 13 teeth can be chosen and meshed together in a line. The first gear is turned a given number of times, and the student must predict the number of turns (usually a decimal) the last gear will make. There are variations to this exercise.

Educational objectives:

To assist in developing certain problem solving skills such as;

- . identifying multiple solutions
- . analyzing
- . working backward
- . looking for a pattern or sequence
- . using a model
- . information gathering

PRESENTATION

	Impressive	Satisfactory	Unsatisfactory
Accuracy	X		
Documentation		X	
Screen display	X		
Technical characteristics		X	

	Impressive	Satisfactory	Unsatisfactory
Feedback		X	
Provision of help		X	
Record keeping		X	
Reward		X	
Motivational level		X	

OVERALL COMMENT

Excellent		Recommend purchase	
Pretty good	X	Consider purchase	X
Fair		Seek better program	
Poor		Not recommended for purchase.... (See Special Notes)	

SPECIAL NOTES

The program is not as widely applicable as another Sunburst program, The factory. Only the better students will discover the relationships necessary to predict the turns made by the last gear in the line. Once the required formula is discovered, the program loses its motivational effect.

A large school may find Gears useful in demonstrating a practical use for division of numbers

NOTE : An interesting off-computer support activity would be to have students use gears from the Lego range, in order to establish initial ideas on direction of rotation in a gear train.

Evaluator/s W. McConnachie **Date** 17.6.86

7. Dissemination of Reviews

Dissemination of reviews within and between countries was seen as a means of maximizing available resources within the region.

Priority should be given to the distribution of factual descriptions and operating characteristics of software, rather than opinion or context specific information.

There is also a need among countries in the region for information to be disseminated concerning types and availability of software, and its possible uses within the classroom.

8. Copyright and Piracy

Software can be thought of in the same manner as books or other intellectual properties. Each country in the region has policies concerning the ownership of software.

If permission to copy or distribute is not contained within the package, then duplication (in the absence of consent of the holder of the copyright) is a breach of copyright.

The laws and policies concerning copyright must be adhered to strictly. However, efforts should be made to ensure that dissemination of software should be under conditions which maximize the use of available resources within and across educational systems.

Such dissemination and distribution can only be made with the copyright holder's consent.

9. Regional Co-operation

The development of mathematics software is time consuming and expensive. Many countries will not find the resources to undertake this development, and it is desirable not to duplicate efforts across the region, if possible. The transfer, exchange and purchase of software may be difficult because of copyright, language, or machine compatibility. However, it may be possible to negotiate an exchange of the design specifications for particular software, or the programme listing. This would allow for both the easy adaptation and the translation of the written code.

Chapter 5: The Teacher: Development and Support

The success of any curriculum innovation depends on the teachers who implement the change, as well as the materials for the innovation. Experience has shown that the key to effective implementation is the teacher. It is necessary to find out about teachers, their background, and their ability to use computers effectively in order that development and support programmes can be efficiently planned.

1. Teacher Profile

From a survey of the thirteen countries involved in the development of this monograph, it was evident that fewer than half of the teachers of mathematics in these countries are able to use computers.

Most teachers would not have undergone a computer literacy course or a computer programming course as part of their mathematics courses or teacher education courses. In some countries, recently trained teachers would have had some computer training in their pre-service education courses.

Some practising teachers, on their own initiative, have studied computer programming as a hobby or have taken a course related to computing or programming. Some other teachers have been sponsored by their schools to attend such courses or have been trained by computer firms servicing their schools.

Because of the prevalent use of computers in computer literacy courses and programming courses in secondary schools, two groups of teachers with different sets of attitudes have evolved. Teachers with no experience in using computers feel that using a computer needs considerable programming knowledge, and teachers with experience in programming alone are not aware of the role of the computer in teaching mathematics. This latter group's lack of awareness may be shared by teacher trainees who are in their pre-service education.

There is a need to initiate teacher development and support programmes that will provide teachers with sufficient proficiency in using the computer as a tool in teaching mathematics, as well as promoting the conviction that computers can enhance learning. These programmes may be classified into the following three areas.

2. Pre-service Education

Initial teacher education occurs in university mathematics departments, mathematics education departments, colleges of education, teacher education colleges, and nursery or kindergarten teacher education centres. Experience in the use of computers in teaching mathematics should be incorporated into existing courses which look at techniques and methods of teaching. Mathe-

matics departments should encourage the use of computers in their courses.

Courses involving computers are now part of undergraduate programmes in many countries, and these can be augmented with courses that enable teacher trainees to use more content-free packages, as well as provide them with experience to use authoring systems. Because of LOGO's capability in developing conceptual mathematics thinking, it would be beneficial to include a course on LOGO in pre-service courses.

3. In-service Education

Methods that are successful in existing in-service courses should be used for educating teachers in the use of computers in mathematics teaching. These may be short or long courses.

Short courses usually consider one specific objective, and could be conducted by experts in the field of mathematics with computing background, and/or master teachers. These courses can be conducted by agencies such as:

* educational institutes or centres;
* teacher organizations;
* groups of schools according to location or region;
* resource centres; and
* education authorities.

The content of a short course depends on the needs of the participants, and could be enhancing proficiency in any of the following:

* computer literacy (including the operational use of the computer);
* elementary trouble shooting;
* mathematics software;
* software review skills;
* teaching methods using computers where group work is needed; and
* use of teacher's utilities for class record management or grading purposes.

Long courses usually run for an extended period. Because of this, these courses could be held during vacation time or during the school year, and these need the support of education authorities.

Content of such courses may include the following:

* a selection from the topics for short courses (indicated above);
* areas of mathematics which can be supported by computers easily;
* introduction to the use of computers in teaching;
* the use of spreadsheets in mathematics;
* programming in LOGO; and
* software production, including design and development.

Other ways of encouraging professional development may include:

* Advisers: Team-teaching with advisers has been done in some countries where an expert works in a school with selected teachers. This enables the training to be done locally and tailored to the existing conditions in the teacher environment.

* The 'cadre' system: This is based on a system of 'echoing' which has been done in some countries and involves sending at least two teachers from a school for training. These teachers then go back to the school and train other teachers.

* Distance education: This involves media, particularly television or video and could be a good vehicle for disseminating information on the computer's role as an aid in mathematics teaching.

4. Teacher Support

Efforts to ensure effective use of computers by mathematics teachers must not stop at the end of pre-service or in-service courses. Teachers must be given support constantly, in the following two ways.

a) Administrative Support

Administrative support should be given in making decisions regarding the number, the placement and the use of computers in a classroom, in software acquisition, and in encouragement to experiment with different classroom strategies.

b) Professional Support

Professional support may come in the following forms:

* Software packages should contain documentation to help teachers use them in their mathematics teaching. Materials may need to be provided to help build up the teachers' self-confidence in using particular software effectively in their mathematics lessons.

* Regional centres could serve as software libraries, sources of teacher information (especially software reviews), in-service centres, and maintenance centres.

* Newsletters, journals and other such publications must continually publish reviews, notices about new software, case studies illustrating the use of computers in mathematics teaching and other information about computer use in mathematics.

There may be other vehicles for teacher support in particular countries. It is important that this support should be provided on a continuing basis to enable teachers to effectively use computers in their mathematics classroom.

Chapter 6: Other Issues

Throughout this document, numerous challenges involving mathematics and computing have been raised. This chapter addresses some other issues, which are of more general interest.

1. Resource Management

Questions concerning the management of computer resources need to be considered by national and local educational authorities, by school administrators, and by individual departments within schools such as the mathematics department. These questions relate to software packages, hardware, scheduling and maintenance.

a) Software Packages

Software compatibility between machines is often a problem. When authorities are trying to equip many schools with software, should software compatibility be considered?

Many people suggest that a clearing house would be desirable to assist in the distribution of software packages. Is this a national or a local responsibility? Should all teacher-produced software be held in such a clearing house or only approved materials? Such a clearing house, or any other suitable organization should have an annotated catalogue of software materials to inform teachers and students about what is available and where it can be obtained. Who should take the responsibility for such a catalogue? Should it be electronically accessible so that it can be readily updated or would this mean that fewer schools would use it?

Some school libraries lend software. These libraries should contain a computer so that borrowers can preview the material. Each school needs to decide on its library's role in software purchase, storage, cataloguing, lending and viewing.

b) Hardware

When schools have a number of computers, a major issue is whether the computers should be in one room, or in a number of rooms. The response depends on how classrooms are managed and what teacher and software expertise is available. Some schools try to increase their number of computers to get a fully equipped computer room with one machine for either one or two students. These schools then find that other ways of distributing computers would enable them to be used more effectively. Within financial considerations, schools must know how they wish to use their computers before they can make this choice.

Another issue affecting computer use is whether or not they are networked. Different schools will come to different conclusions. In general, classroom networking is only desirable if 'whole class' teaching is the main method of using computers. This is less emphasized now in countries that have

had computers for some time.

Wide-area networks link a number of computers or terminals in different classrooms or schools so that they can share or exchange information.

c) Scheduling

With a limited number of computers, schools need to determine ways of scheduling their usage to maximize their benefits. This will be necessary in the cases where one fully equipped room, or where only one or two computers are available in a room. The individual teacher will need to ensure that all students have scheduled opportunities to use the computer in their mathematics classes.

d) Maintenance

Both software and hardware have associated maintenance problems. With software, the making of back-up copies is advisable. With some software this may breach copyright and with certain others permit copying for further payment.

Maintenance of hardware is often expensive. Some groups of schools or individual schools take out maintenance contracts. While a machine is being repaired, a standby machine is desirable. One or two governments have arranged for service contracts through local resource centres where a faulty machine can be quickly exchanged for one in working order, through maintenance facilities.

Finally, some schools have electronic groups that may carry out minor maintenance, but this practice could breach service contract arrangements.

2. *Equity*

a) Availability of Machines

When it is impossible to ensure that all schools can get computers, some schools may get them, either through Parent Teacher Associations (PTAs) or community or funding agencies. Should educational authorities support these schools or should they use equity funding policies to ensure that schools without alternative support systems are still able to provide computer access for their mathematics classes?

A further associated issue in some countries concerns assistance to nomadic schools. One strategy may be to supply hand-held solar-powered calculators until portable computers are available.

b) Language

In countries where a number of languages are used, selecting one language often has advantages in terms of development and availability of software. In some countries this may be English, in others it may be the predominant language which is supported first. For some others, it may be a

language that is transliterated into Roman script. Because of these factors, extra resources may need to be allocated to ensure equity between language groups.

c) Gender

In some countries, either boys or girls may dominate the use of computers, and the available software may reflect only their experiences and interests. Mathematics teachers must ensure that boys and girls have similar opportunities and are encouraged to participate fully in mathematics with computer activities.

3. *Assessment Assistance*

The computer may be used to assist the teacher with many tasks.

* Test items may be stored and generated by the computer. These items may be used in the speedy construction of test and examination papers. New items can easily be added and existing items modified or deleted.

* Self-testing is possible with some software and immediate feedback may be provided. An incorrect response may be followed by a short tutorial explaining the topic and the correct answer. A further question may be set to complete a remedial cycle. If time is important, a limit may be set on each question or a record of the total time taken for a test may be recorded.

* Recording of students' marks and the scaling of marks is a further aspect of assessment where a computer may assist the teacher, and this process can be extended to incorporate the production of subject reports, comprehensive school reports and certificates.

4. *Producing Resources*

Computer resources may be better used if a computer were available to assist teachers in the preparation of materials.

Computers may assist the preparation of

* Work sheets with high quality graphics, layout and printing;
* Overhead transparencies and displays; and
* Tests and other examinations.

Teachers may also gain familiarity with computers by using them in this way.

5. *Outside the Classroom*

Some students have computers at home, some have access through commercial institutions to computers outside school, some school libraries loan equipment outside class time and some students use computers through com-

puter club activities. Teachers should ensure that students without access to computers will not be disadvantaged.

When some students have access to computers they could be encouraged to develop software for others to use, and to work on their machines outside school hours so that more class time with computers is available for other students.

Other work with computers outside formal lessons could be encouraged. This might include computer literacy, mathematics computing clubs, programming workshops, mathematics with computers competitions, and so on. Such use may suggest advantages to those students with access to computers. Care must be taken to minimize this imbalance.

6. *Co-operation and Coordination*

Co-operation in the areas of computers and mathematics needs to be encouraged between schools, professional associations, individuals, various agencies, and government, in terms of development of software, exchange of ideas, experiences and expertise, and to facilitate the acquisition and maintenance of software and hardware.

Coordination is desirable between the various levels of any education system in terms of mathematics content and computer use, and between curriculum planners and teacher trainers to ensure that trainees are ready for the classrooms of the future.

Schools must be involved with this process as it broadens the use of their limited resources and helps provide training for teachers.

7. *Research*

Much that is assumed about computers enhancing the teaching and learning of mathematics, is based on experience and expert opinion, but very little research work has been published on the topic. It is desirable that a more extensive programme of research be developed to:

* determine how well and how fast students learn mathematics, and how they retain or transfer this learning when it has involved computers compared with traditional learning modes;
* study the psychological aspects (including motivation and group dynamics) of computers in mathematics;
* find the effect of specific uses of the computer in mathematics (e.g. authoring systems);
* study the effect of computer use on the time needed to complete particular mathematics courses; and
* study the effect of different numbers of computers in classrooms on mathematics learning.

8. Finance

At all levels of administration, decisions need to be made about how to use the limited resources that are available for computing in mathematics. A balance needs to be struck between hardware costs, software costs, teacher training, and maintenance. The balance will be influenced because decisions affecting different items may be made at different levels.

Most activities involving mathematics and computers have financial implications. The first set of costs - the capital costs to purchase hardware - is followed by:

* the cost of software;
* the cost of maintenance;
* the cost of replacing and upgrading obsolete hardware; and
* the associated costs of teacher development.

As there is no easy solution to the problems of limited resources for education, it is important that some financial commitments be made, that pilot schemes be established, and that the long term goal of ensuring that all students of mathematics have access to computers be recognized.

Chapter 7: Summary and Recommendations

A summary of each chapter is provided as a background to the recommendations. In some recommendations, agencies have been identified. In others, international education authorities, curriculum authorities, research agencies, tertiary institutions, schools, professional associations and commercial concerns, could take up the recommendations.

1. *Introduction*

The increasing availability and use of computers in society has affected the education system. Consequently, computers are being introduced into schools for computer awareness, administration, an aid in teaching some subjects and other activities. Mathematics has been affected by the introduction of computers and steps should be taken to ensure that the curriculum and teaching and learning methods reflect the computer's use in society.

Recommendation 1:

That education authorities take steps towards providing at least one computer for each school.

2. *The Mathematics Curriculum: Innovation and Change*

The capabilities of the computer and its possible uses in mathematics teaching and learning may affect the mathematics curriculum. With the possible changes caused by computers in mathematics teaching and learning, the curriculum needs to be reviewed in terms of enhancement of some topics and processes and a change of emphasis in others.

Recommendation 2:

That education authorities be alerted to the impact computers can make on the mathematics curriculum and the increased need for curriculum review.

Recommendation 3:

That an analysis of the mathematics curriculum be undertaken to determine priorities in the areas that are to be enhanced by the use of computers.

3. *The Mathematics Classroom: New Ideas with Computers*

The way that computers can be used in mathematics to improve students' learning experiences and what teachers do are considered. Suggestions are made concerning the types of software that may be useful for this improvement. Some ways computers can be used in situations according to the number

of machines available and their deployment, and some comments regarding the ideal number of computers in a mathematics classroom are considered.

Recommendation 4:

That the use of computers in the teaching and learning of mathematics is strongly recommended.

4. *Software: Quality and Development*

Need for dissemination of information about quality of software to teachers is discussed. Effective dissemination of information to teachers would enable them to make full use of the software. Additionally, some topics in mathematics where further software development is needed are identified and strategies for this development are discussed.

Recommendation 5:

That the exchange of software, software listings and design specifications be commenced and encouraged between countries on both a formal and an informal basis.

Recommendation 6:

That a mechanism to review software and to collect and disseminate these reviews be set up in each country.

Recommendation 7:

That a mechanism for exchanging and disseminating reviews of software and annotated catalogues of software within the region should be supported.

5. *The Teacher: Development and Support*

The needs of teachers of mathematics regarding pre-service education and in-service professional development and support are discussed and particular suggestions made for the content and operation of such programmes.

Recommendation 8:

That teachers be equipped with the appropriate mathematics curriculum knowledge and techniques to enable them to use computers in their teaching.

Recommendation 9:

That attention be paid to computer usage and techniques in mathematics for pre-service teacher education.

Recommendation 10:

That attention be paid to computer usage and techniques in mathematics for teacher in-service development programmes.

6. *Other Issues*

Allocation of resources is considered in relation to the optimal number and placement of computers, their compatibility and networking possibilities. Equity issues that are generated by the introduction of computers may be solved by careful computer usage. The need for research, co-operation and coordination was identified.

Recommendation 11:

That equity be promoted and maintained in the deployment of resources.

Recommendation 12:

That effective coordination occurs between the various agencies in an education system responsible for mathematics and the use of computers.

Recommendation 13:

That research into various aspects of teaching and learning with computers in mathematics be encouraged and supported in all countries.

7. *General*

Recommendation 14:

That Unesco initiates publications devoted to mathematics with computers.

Recommendation 15:

That further meetings be held for the following purposes;

* follow-up workshops to monitor trends and exchange reports;
* training workshops in the process and techniques for generating quality software for all school levels; and
* training workshops at the regional or sub-regional level on the use of computers in mathematics.

Appendix 1: List of Participants

Participants

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Appendix 2: Country Report Summaries

1: AUSTRALIA

1. *Introduction*

Australia has at least six different mathematics curricula and these are administered by each of the states and territories. Schools show a great diversity in the level of computing resources. Nearly all Australian secondary schools have some computers, and it is estimated that more than 75% of primary schools have at least one. Some schools have a large number of machines (giving a student: machine ratio of less than 10:1), other schools which do not have electricity (usually in nomadic communities) have none. There are also 'Correspondence Schools', which serve students in remote communities, and in some hospitals, which present special problems in machine supply.

Most computers in Australian schools have been provided through state and Commonwealth funding. The level of these resources is based on a decision at school level or at regional or state level. However, there is an increasing interest and demand for computers, and in many cases this demand is greater than available resources can provide.

The Commonwealth Government funded a major programme in 1984-86, which, in many states, provided the impetus and funds to implement the use of computers in schools, through professional development, generation of resources, and hardware and software provision.

2. *Curriculum Development*

The introduction of calculators brought a change to the style of examination questions at senior levels in many states, but did not initially change the syllabus. However, the prevailing trend in curriculum review and development indicates that changes are needed to respond to the introduction of computers.

The Australian Association of Mathematics Teachers regards the issue as so important that it has organized a strand within the next Annual Computer Education Conference, the meeting of Australian Computer Education. There is also an increasing number of papers being published on the subject.

The following considerations apply:

a) the natural inertia of curricula, where changes may take 3-5 years to implement.

b) the questions of which areas will be effected, and in precisely what manner.

c) the problem of what are the skills which need to be taught for

the efficient use of computers in mathematics.

3. Learning and Teaching

Most Australian schools have tackled the area of 'computer education', but apart from options available in senior syllabi, very few courses insist on the use of computers in mathematics. As well, there are perceived differences in the way teaching occurs with computers. The number of available machines is a major determinant and the type of software available is another.

As microcomputers have only been available within the last five years, many teachers are not yet familiar with them. Thus general classroom practice may need modification with attention to the uses of all forms of technology in mathematics.

4. Software Review and Development

Most Australian education departments initiate software manufacture, publish reviews, or modify existing material. The emphasis is now on courseware - material that accompanies software to support its use in the classroom. Most packages now distributed by state authorities contain teaching and support notes.

Mathematics has been well served by software developers and software is available for;

- Drill and practice
- Tutorials
- Packages supporting such activities as LOGO, or spreadsheets
- Databases
- Graph plotters, and other activity software.

These packages are generally sold cheaply ($20 - $60) or distributed free.

5. Teacher Support and Development

All Australian states conduct in-service activities for their teachers. The level varies. There have been specific in-service courses in some states concerning computers and mathematics but the number of these is not high.

Teacher pre-service has covered some aspects of computer use in classrooms, but there is a time lag between planning of courses and their implementation in teachers colleges.

6. Issues

A number of issues are emerging, many of these concern the distribution of resources and are typified by such questions as:

- What is the ideal number of machines per classroom, or per school?
- Should computer education be taught as a formal subject?
- What are the best ways of using computers in mathematics?

2: BANGLADESH

1. Introduction

Education in Bangladesh is divided into four levels; Primary (classes 1 to 5); Secondary (classes 6 to 10); Higher Secondary (classes 11 and 12); and Tertiary (College, University, and Professional and Technical Training).

After Higher Secondary level a student can be admitted to any of the tertiary institutions.

In the light of the recommendations of a National Committee for Curriculum Development, mathematics textbooks for schools have been published by the National Textbook Board with the cooperation of the Bangladesh Mathematical Society. These books are being used for the teaching and learning of mathematics at primary and secondary levels.

In the Primary level, the mathematics curriculum and teaching methods are designed so that a student can acquire sufficient knowledge and skills for solving elementary mathematical problems and applying these in everyday life. At the secondary level, mathematics, more emphasis is given on the techniques of problem-solving in arithmetic and algebra and geometry are introduced to enable students to acquire mathematical concepts and develop analytical thinking. Students are introduced to statistics and demography.

The Higher Secondary is the stage of pre-university teaching. A student is taught almost all the necessary mathematical tools including calculus and analytical geometry, as preparation for study at university. Science courses are offered at the Higher Secondary level. A student studies mathematics not only as a separate subject, but also has to learn the applications of mathematics for physics and chemistry courses. After Higher Secondary education students can study medicine, engineering or can go to the university to study the Arts and Humanities, Commerce or Science depending on their interest and merit.

2. Computing

The first computer in the country was installed in the late 1960s at the Atomic Energy Centre, Dhaka. Gradually, computer facilities became available to the students and teachers of the University of Dhaka and the Bangladesh University of Engineering and Technology at Dhaka who were engaged in research activities in the different branches of science, engineering and social sciences. Computer education began at that time with training programmes, seminars and computer literacy courses around this computer. Now computers are being used by government, semi-government and private organizations for data processing, storage of information and other administrative purposes.

At present there are 44,200 primary schools, 9,440 secondary schools,

616 higher secondary schools and colleges, and 7 universities in the country. Out of the 7 universities, the University of Dhaka and the Bangladesh University of Engineering and Technology at Dhaka have their own computers. Microcomputers are being used by some private schools, colleges and educational institutions for administration, but there are no programmes for the use of microcomputers in science and mathematics teaching in the public sector schools and colleges.

3. Curriculum Development

Recently, the Bangladesh government constituted an Education Commission to suggest measures for the improvement of education at all levels. In view of the rapid growth and importance of the use of microcomputers in science and mathematics teaching, it is expected that the Education Commission will have a recommendation to explore the possibility, feasibility and social impact of the use of microcomputers in some public sector schools on an experimental basis.

3: CHINA

1. Introduction

In China experiments in computer instruction started in 1978. Since 1983, selective computer courses have been offered in some better equipped secondary schools throughout the country. The objectives of the courses are to develop the students understanding of the basic architecture of the computer, to enable them to write simple programmes (mainly in BASIC), and to teach them how to use of computers and software. Currently, more than 3,000 schools have computers (about 34,000 units). In 1984 the former Ministry of Education approved "The Syllabus of Selective Computer Courses in General Schools (Tentative Draft)". As a result of this, more than 20 different teaching materials have been published in various provinces. From 1983 to 1986, about 350,000 secondary students were trained in computer courses at various levels and experiments on computer instruction were conducted in a few primary schools.

In order to promote computer education and CAI, the following measures were taken:

1) Two centres of computer education in secondary schools were set up in Beijing and Shanghai, focusing on research in computer education and the development of CAI software.

2) A unique computer the 'Zhonghau Learning Computer' and educational software for teaching with this in secondary schools and for individual learning activities in families is being produced.

3) The Shanghai Centre of Computer Education has started to register and classify the instructional software packages developed by the various schools and teachers (the first issue of the National Catalogue of Educational Software has been published).

2. *Curriculum Development*

In considering changes to the school mathematics curriculum, five principles need to be taken into account. These are:

1) The Principle of Serving the Goals of Education

The goals of education are to train and develop manpower for the society, and to foster the abilities of independence. Hence, the selection of contents should take into consideration the students current needs as well as future needs.

2) The Principle of Efficiency

The knowledge and abilities which primary and secondary education provides to students should be those which are needed by most students as soon as they leave schools. The knowledge which is needed only by a small number of students after leaving school could be learnt when it is needed. This saves time and improves the efficiency of learning.

3) The Principle of Gradual Change

The learning environment is an entirety. Any change in one aspect is bound to have implications on other aspects. Changes in the contents of mathematics should therefore be made gradually so that parents and the public will be able to accept them.

4) The Principle of Conformity with the Students' Cognitive Abilities

In order to ensure that students fully understand the contents of mathematics, it is necessary that these contents are organized in a way that conforms with the cognitive abilities of the students.

5) The Principle of Adaptability to Computing Tools

Computing tools such as the abacus and stick-computing methods have greatly influenced the teaching of arithmetic in China. The introduction of computers into primary and secondary schools is currently influencing the teaching of mathematics.

Because of the use of microcomputers, some traditional contents in the school mathematics courses have been simplified or deleted. The topics affected are as follows:

(a) The requirement for performing the operations with numbers has been reduced, and calculators will used in the junior secondary course.

(b) Some traditional sections such as 'approximate calculation', 'calculation with logarithms' and 'logarithmic scale' have been removed from textbooks at the secondary level because of the use of calculators and microcomputers.

(c) Calculation with trigonometric functions at the senior secondary level has been simplified.

By using microcomputers, the following topics can be enhanced or added:

(a) Simple statistics has been added to the third grade of the junior middle level. This includes populations and samples, average, variance, simple methods of calculation of variance, frequency distribution, and cumulative frequency distribution.

(b) Determinants and matrices.

(c) Some topics of discrete mathematics, such as permutations, combinations and probability need to be added. These topics are used not only in daily life but also in learning computer literacy and programming.

(d) Some used methods of optimization, such as linear programming (without including the basic theory of optimization) for the secondary level.

4: INDIA

1. Introduction

Computers have been in use in India since the late sixties but were not used for educational purposes until sometime later. Eminent educationists and Commissions, in papers and reports, have stressed the need for the introduction of computers in education. Consequently, the following programmes were introduced:

a) In 1979, a programme on micro-processor education was started at graduate and under-graduate levels to train teachers from various engineering colleges which would later offer the subject for study in their colleges;

b) In 1984, a computer literacy programme, called the Computer Literacy and Studies in Schools (CLASS) Project was started in 250 selected schools from all parts of the country on an experimental basis. This programme was expected to be extended to other schools after the pilot phase.

2. Computer Education Programmes

Computer education programmes are available at engineering colleges, universities, polytechnics, industrial training institutes, and schools.

In engineering colleges/universities, the following programmes are available:

a) Four-year Bachelor degree (B. Tech.) programme in computer science and engineering;

b) Master's degree (M. Tech.) programme in computer science and engineering;

c) Three-year Master's programme in computer applications;

d) One-year Computer Appreciation (DCA) programme.

In polytechnics/industrial training institutes, the following programmes are available:

a) Two-year diploma in computer applications;

b) Training programmes for Console Operators (one-year) and Data Preparation Assistants (6 months) are available in industrial training institutes.

In schools, the main courses where computers are used are;

a) Computer Science Course

The computer science course is being offered as an elective subject for students at the senior secondary level in some selected schools. The focus in this course is on the teaching of the subject in detail to a small minority of students who offer it as an elective and will take an external examination at the end of their schooling.

b) Computer Awareness Programme

Computer awareness programmes organized under the Computer Literacy and Studies in School (CLASS) Project, are being run by the collaborative efforts of the Department of Electronics and the Ministry of Human Resource Development, Government of India. The National Council of Educational Research and Training (NCERT), an apex body engaged in research, development, training and extension programmes in all areas of school education, is the national coordinating agency for the project. Under this project, computers are being introduced in some selected secondary/senior secondary schools.

Fifty resource centres, including one at NCERT, have been set up throughout the country to assist in the implementation of the project. The pilot phase expects: i) to provide students with a broad understanding of computers and their use; ii) to familiarize students with a range of computer applications and its potential as an information processing tool; iii) to demystify students about computers and to develop ease and familiarity with them to help develop individual creativity in identifying and developing applications relevant to the student's immediate environment; and iv) to encourage teachers to use the technology in improving their teaching.

BBC Microcomputers were given to 250 schools for the pilot phase. (Semiconductors India Ltd. now manufactures BBC Micros, with the name UNICORN, under license.) In 1985-86 and 1986-87, 496 and 500 schools respectively were added to the project.

Fifty resource centres have been selected from institutions engaged in computer education including university departments, engineering colleges and technical teacher training institutes. When selecting the schools, care was taken to ensure that they were within 50km of the Resource Centre to which they were attached.

The responsibility for computer maintenance was given to CMC Ltd. and it was decided to keep additional computers at the Resource Centres so that the schools could exchange working computers for defective ones.

The curriculum for training of teachers at the resource centres includes a working knowledge of packages such as word-processing, database management, LOGO graphics, spreadsheets, and some computer-based learning packages suitable for schools.

It was agreed to train three teachers from each selected school. Consequently 700 teachers were trained in 1984 and about 2,300 more teachers were trained in 1985 and 1986. They were trained in three-week intensive courses on the above packages with a considerable amount of time spent getting hands-on-experience.

c) Vocational Courses

Students taking various trade courses in the vocational stream at the senior secondary stage will be given experience with computers if they opt for courses requiring these.

3. Teaching of Mathematics and Computers

At present specific use of computers is not being made in the teaching of mathematics. Computers are available in a small proportion of schools, but no uniform policy for use in the teaching of mathematics has been made. In schools, where computers are available, the teachers sometimes demonstrate the software packages that are available when that concept is being introduced. Some mathematics packages available are: Algebraic Manipulations, Geometric Transformations, Mathematics with a Micro, Rekha, Question Bank, and Highest Common Factor.

The National Education Policy Document clearly indicates that the mathematics curricula will have to be redesigned due to the introduction of computers in schools, but this may take some time as: i) a uniform change in curriculum could be reflected only if computers are made available to all the schools where the change is tended to take effect, and until then, either the current curricula will continue or a differential curricula for schools where computers are available may be followed; ii) teachers are not yet ready for the change; and iii) adequate and suitable software is not yet available for most of the topics even at the secondary/senior secondary stage.

4. Software Review and Development

Various software organizations, individual programmers, resource centre personnel and teachers are producing software packages which can be used in

the teaching of mathematics and other subjects. Although the situation regarding software development is improving, there is a long way to cover before a complete set of packages for teaching the entire curriculum in mathematics could be prepared, even for senior secondary schools.

NCERT, the national level coordinating agency is responsible for the evaluation and selection of software packages for the CLASS Project. For this, a committee of subject-experts, educationists, practising teachers and faculty members with suitable background is constituted for each subject. Each committee evaluates the software according to the norms prescribed by the Evaluation Committee for the purpose, and one such committee considers the software packages for mathematics.

5. *Teacher Training*

Mathematics teachers attending training programmes under the CLASS Project are graduates and post-graduates in mathematics with degrees in education. Only a few of them have had computing experience before attending these courses.

Teacher training programmes under CLASS Project are held twice a year. Each programme is of 3-weeks duration in which, in addition to the topics mentioned before for teacher training, the trainees are taught about the educational implications of the software packages they work with and they are given hands-on-practice with the packages so that they can use them in their schools.

6. *Other Issues*

(1) It is hoped that during next years, a majority of the secondary and senior secondary schools will be covered under the Computer Literacy Programme. Strategies will have to be developed to accelerate the training of teachers from those schools with the help of the mass media. The inclusion of this programme in the syllabuses of teacher training institutions will also help accelerate the process by avoiding retraining of those teachers after they join the schools.

(2) The preparation of translated versions of the documentation for existing software packages will make the use of these easier for students whose medium of instruction is not English. Efforts are being made to do this and to enhance the results of the Computer Literacy Programme.

5: INDONESIA

1. *Introduction*

Microcomputers have been available in Indonesia since 1981. They are not evenly distributed throughout the country as most of them are concentrated in the big cities, such as Jakarta, Surabaya, Bandung.

In the cities, microcomputers are at the homes of those who can afford them. Microcomputers are also available in offices for secretarial applications, and are concentrated at non-formal education institutes. Only a very few schools could equip a laboratory with microcomputers.

As an illustration, we can consider school microcomputers in Jakarta. Jakarta has about 350 senior secondary schools in which about 85 are public schools. Of these schools, less than 30 have microcomputers in their laboratories and most of these are private schools.

This means that for educational purposes, microcomputers are mostly concentrated in commercially managed non-formal education institutes rather than at formal schools. These institutes offer microcomputer courses ranging from microcomputer operation to microcomputer programming. Some offer CAI for school children parallel to the school curriculum and those CAI include mathematics courses.

2. *Curriculum Development*

The senior secondary school curriculum referred to as the 1984 Curriculum contains knowledge of microcomputer. It is intended to be integrated into the mathematics programme, but for the purposes of the topic on microcomputers it is treated as a separate entity. This topic includes microcomputer operation, package programme utilization, and programming. The study of these makes no special reference to mathematics.

In Indonesia, there is a controversy regarding what computer languages to use. Some educators accept the reality that computer languages are English based, some educators advocate the use of computer languages which are Indonesian based, and now two versions of Indonesian based computer languages are available.

3. *Learning and Teaching Models*

There is still no learning and teaching models for mathematics modified because of microcomputer in schools. However, in non-formal education institute, many school subjects including mathematics are being taught with microcomputers and the learning and teaching of this is done through CAI which contains tutorials, demonstration, and exercises. With the minimum aid from the instructor the students could run and learn the programmes by themselves, but until now, the mathematics CAI programmes are limited to the elementary level, and the number of software packages is very small.

4. *Software Review and Development*

Most of the mathematics software in the market come from abroad. They are written in English which is not familiar to the students and therefore they are not being used.

The mathematics software which is used in the non-formal education institute is usually produced by the particular institute, but this software is

now being sold publicly. Since they are new and scarce there are no reviews available about them.

5. *Teacher Support and Development*

As early as 1982, IKIP Jakarta offered microcomputer courses to its students. Since these students will become teachers of secondary schools, these courses could be considered as teacher support and development.

Teacher training and computer science colleges offer short term microcomputer courses to the mathematics teachers during vacations, but the number of teachers and schools involved is very small so these efforts are only a minor part of teacher development.

6. *Issues*

The major difficulty is the supply of computers to schools. Several professional groups occasionally suggest the use of computers in schools. One suggestion is that regional microcomputer centres should be established where schools in the region could make use of the microcomputers available at that centre. Another suggestion is that cheap computer should be made available to schools. A further suggestion is to introduce microcomputer literacy at school through reading and visiting computer centres. Yet another suggestion is for parent-school associations to provide microcomputers to their schools.

This means that the availability of school computers depends on the effort of each school.

At the moment the non-formal education institutes carry the biggest part of microcomputer education for the students including the use of microcomputer for teaching and learning mathematics.

6: JAPAN

1. *Introduction*

Microcomputers have been used in various forms in Japan since the late 1970s, The number of personal computers produced in 1986 exceeded two million and probably more than 10% of school children in large cities have a computer in their homes, but in schools the scene is slightly different. In 1986, 2% of elementary schools, 14% of lower secondary schools and 81% of upper secondary schools had more than one microcomputer. While success is demonstrated in experimental schools of microcomputers, there are still many teachers who totally ignore microcomputers. In spite of social pressures and governmental support, the use of microcomputers is limited in all schools and especially at elementary level. One possible reason for this is the lack of suitable software.

2. Curriculum Development

The government has plans for the use of computers in education, and currently the revision of the Courses of Study are being undertaken. At the moment the word 'computers' is only used once in Mathematics II in the upper secondary selective mathematics course and computers are not referred to in any other courses of study for mathematics.

Under these circumstances, the mathematics education society started a review of the objectives and contents of the mathematics curriculum. Their considerations were from the following points of view: what mathematical literacy is required for all citizen in a highly advanced information society; what mathematics is needed as a basis for computers and information science; how can the higher educational objectives of creativity and problem solving be attained; what changes in the degree of difficulty of topics and in the order of presentation of materials are implied by introduction of computers; etc. The Japan Society of Mathematical Education made public its proposal on the importance of mathematics in an information society, suggested to promote the use of microcomputers in the teaching of problem solving, and indicated contents to be covered for computer education. There is a considerable time lag between the pressures caused by microcomputers and curriculum development in mathematics. There seem to be two major reasons for this. One is the entrance examinations from lower secondary school to upper secondary school and from upper secondary school to university. These exert severe pressure on school mathematics and it seems that teachers think chalk and blackboard style teaching is more effective than a computer style for the entrance examinations, and computers are not used in the entrance examinations. Another possible reason for this is the teachers' attitude towards school mathematics as pure mathematics. On the other hand, some of the graphic features of microcomputers attract mathematics teachers, so we may see a change in their attitude towards computers.

3. Teaching and Learning

Most teaching and learning is conducted in a whole-class style and the number of students in a class is about forty. The average number of microcomputers per school is 3 at elementary and lower secondary levels and 10 at upper secondary level. One microcomputer per class is usual at elementary and lower secondary levels and one microcomputer for several students is normal in a class at upper secondary level. Microcomputers are not yet used for individualized learning, and are mainly used for 'Explanation and Drill' at elementary and lower secondary levels and 'Demonstration' at upper secondary level in both mathematics in particular and education in general. Though problem solving is emphasized by the mathematics society, microcomputers are not used widely for it. This may be because of a lack of good software and a lack of good problems for problem solving.

4. Software

In schools teacher-made software is predominant at all levels and commercial software is not very common. In mathematics the software is used for drill and practice in the study of numbers, for graphic display and simula-

tion in the study of functions and geometrical figures, for graphic display in the study of statistics, and for simulation in the study of probability. BASIC is the most popular computer language used, in addition experimentally LOGO is used at elementary level, and PROLOG, PASCAL and LISP are used at secondary level. There are several problems to be solved in relation to the development of software. Compatibility between computers is not common among the available machines. The language used for programming is English, and this causes teachers to fear the computers. Translation from English software is very difficult. Non-roman characters on the screen need greater screen resolution and more machine capacity if they are to be drawn clearly, etc.

There seems to be three types of courseware developers for school mathematics: mathematics educators who are familiar with programming languages; mathematics educators who are not familiar with programming language but utilize authoring systems; and non-mathematics educators who are familiar with programming languages. The first group of teachers develop various kinds of courseware mentioned above, but the number of courseware developed is rather small due to the limited time available for these teachers. The second group tends to develop tutorial courseware on a commercial basis, but it is difficult to make attractive courseware for mathematics teachers. The third group tends to develop drill and practice courseware. Each type of development needs improvement. Though coordination between school teachers and researchers and between the educational society and commercial enterprises exists now, this needs to be further strengthened.

The need to evaluate courseware from the mathematical as well as educational and psychological points of view is emerging. In this regard the improvements in machines and in courseware development systems should lead to better courseware.

5. *Teacher Education*

Pre-service education for mathematics teachers on the use of microcomputers is usually conducted in universities. The contents are computer literacy which includes operation of computers and computer awareness, and development of mathematics courseware. In-service education is mainly conducted in prefectural education centres. In 1986, 80% of prefectures provided short term training courses which covered computer literacy. Other types of in-service education are research-based voluntary study groups and workshops sponsored by the professional association. Since participation in in-service education is usually voluntary, participants tend to be younger teachers. Teacher education for teachers of all ages is needed.

6. *Concluding Remarks*

Mathematics education with computers has just started in Japan. In terms of the mathematics curriculum, the use of microcomputers may be studied in two directions. One is to examine the areas in which microcomputers could play a key role, and the other is to reorganize the curriculum so that students can do mathematical activities with microcomputers. In both approaches we have to look at mathematics education in the light of the technology.

7: MALAYSIA

1. *Introduction*

Although computers entered the Malaysian scene in 1964, it was not until the arrival of microcomputers that their impact began to be felt in schools. In 1981, the first computer club, a co-curricular activity, was formed in a school. The subsequent entry of cheaper compatibles and clones and the fall in prices contributed to a rapid mushrooming of these computer clubs.

In view of this, the Ministry of Education made a study of the literature concerning computers in education and the programmes and projects undertaken by various countries with a view towards determining the significance and impact of computers in education. The study resulted in the recognition that the increasingly widespread use of computers in society would inevitably require individuals to be appropriately orientated to face the challenges presented, and as such a basic education about computers was considered necessary.

2. *Curriculum Development*

In the Malaysian school system today, computer education is taking place through both the formal and non-formal means. The formal means refers to the subject 'An Introduction to Computers' currently being tried in 20 schools. This project was conceptualized in 1983 with the aim of trying out computer literacy as a new core subject at the secondary level, to provide students a basic knowledge of computers and their uses so that they may become aware of the capabilities of the computer and its role in assisting human endeavour.

The new subject was designed based upon four themes: what is a computer?; what can it do?; how can we tell it what to do?; and how does it affect our lives and society?. It is taught to all students at Form IV (grade 10) in the 20 project schools, for 40 minutes per week. Two teachers from each project school were selected with their interest in computers as the major criterion for selection. Previous experience with computers was not a prerequisite, and teachers from diverse subject specializations were selected. These teachers were given intensive training involving hands-on sessions as well as discussions on teaching-learning strategies for each section of the curriculum. Each project school was supplied with five microcomputers with colour monitors, two printers and a selection of software.

The non-formal means refers to computer clubs in the schools which are carried out as co-curricular activities. At the end of 1986, about 40% of the secondary schools and 2% of the primary schools had such clubs. Most of these clubs have acquired between 1 to 10 computers, with schools in the rural areas generally having fewer computers than those in the urban ones. The purchase of computers by schools is often financed by a monthly collection of fees from students who enroll for computer lessons run by the clubs. There appears to be a tendency for lessons on programming, usually in BASIC, although courses on application packages are becoming popular. In view of the rapid increase of computer clubs, in 1986, the Ministry of Education

issued a booklet entitled 'Guidelines on the Formation and Management of School Computer Clubs'. This booklet was issued to all schools and state education departments in an attempt to streamline and coordinate club activities.

Recent developments in computers in education seem to indicate that while it is important for students to know about computers, it is increasingly more important in this age of information that they learn to find, select, process, interpret and disseminate information for a particular need. Moreover, the significant increase in the number and activities of school computer clubs has brought non-formal computer education to many students at earlier ages of their education. In view of these developments and the feedback from the try-out of the pilot project, the Ministry of Education is now reviewing the content and strategies for computer education in the school system.

Apart from the use of microcomputers in schools for teaching and learning about computers, some school computer clubs use the computers to compile student records, process examination marks for classes and analyze past school examination results. Currently there is no significant activity in the use of the computer to enhance the teaching and learning of mathematics in the classroom.

There are many ways that the teacher could use the computer to improve mathematics teaching and learning. The skill of problem-solving is being given an increasingly greater emphasis in the Malaysian Mathematics curriculum and it is probably in this aspect that the computer could prove a great help. Capitalizing on the high speed of computation and algebraic manipulation as well as the high resolution graphics of the computer, the teacher can help students to carry out various investigations that would aid the development of problem-solving. By using a computer, tedious tasks such as computation, algebraic manipulation and graph plotting can be left to the computer, thus enabling students to concentrate on understanding the problem and trying out alternative strategies to arrive at the solutions. The ability of the computer to generate a greater number of examples will also be a substantial help in the consolidation of concepts and skills.

The teaching and learning of many topics in the Malaysian mathematics programme could be enhanced or extended through the use of computers. Some of these are simple interest, algebraic functions, solutions of algebraic equations, two dimensional geometry, statistics and probability. In the teaching of simple interest, for instance, a lack of relevance is often felt because in many cases in adult life, an individual is not faced with simple but with compound interest. The use of spreadsheet could be employed after students are familiar with the formula for simple interest. The teacher could then help students investigate various interest schemes with compound interest, thus enabling them to have some appreciation of what happens in the case of loans and investments in real life.

3. *Teacher Training*

Generally most mathematics teachers are not computer literate, though mathematics and science teachers are often the first to take an interest in

computers, and a growing number have become computer literate through self-study or by enrolling in short introductory computer courses organized commercially. However, most graduate mathematics teachers who joined the service in recent years would have had the opportunity of taking an introductory course on computers or options in computational mathematics. In the training colleges preparing teachers for the primary and lower secondary levels, there are no special courses on computers being offered, but many of these colleges have computer clubs.

4. *Other Issues*

The area of computers in education is a fast expanding one, and the Ministry of Education is looking into the matter. The nature of future efforts to train teachers to use computers will depend on the policy and strategies for introducing the study into the school curriculum and the use of computers for enhancing the teaching-learning process. The formulation of such policy and strategies is a very serious matter. Not only are there heavy financial implications in the short-term and the long-term, but the types of knowledge and the ways in which they can be transmitted, the preparation of teachers, and the effects in the teaching-learning process and classroom management all need to be considered.

8: NEW ZEALAND

1. *Introduction*

Since the late 1960s some high schools have been involved with computing. Initially their emphasis was on programming and computing was part of senior applied mathematics and an extra-curricular activity. With the introduction of microcomputers this changed and now all high schools and half of the primary schools have at least one computer and they are used in a variety of ways across a range of subjects including mathematics.

Computer awareness courses and computer studies are still popular but the computer is starting to be viewed as more than an aid for enhancement but as an empowering tool that gives students more control over their learning.

2. *Curriculum Changes*

The mathematics curriculum is being influenced in a number of ways:

- Content free software such as word processing and databases are being used in mathematics. The use of spreadsheets is starting to develop.

- Specific interactive packages are being used for graphing, for statistics and for numerical methods. This usage will grow with new packages that solve algebraic, differential and integral calculus equations; manipulate matrices; and solve triangles.

- Simulation programmes are used in probability and statistics.

- Open ended interactive discovery software such as LOGO, geometric supposer and algebraic supposer are starting to influence the way that geometry and algebra are taught and will have an effect on content emphasis.

- Mathematical games, tutorial programmes, and drill and practice software provide motivation and can provide revision material but are only used to a limited extent at present.

The Computers in Education Division of the Department of Education is involved in a series of 'exploratory studies'. These will indicate some future developments and possibilities in all subject areas including mathematics.

3. *Change in the Classroom*

When the whole class can get to a computing room with one computer for each small group of students, then 'whole-class' teaching tends to continue, but in schools which distribute their machines so that one or two are available in each classroom, then the teachers are having to adjust to group work with different activities being pursued at the same time.

When a computer is being used by a small group of students then discussion is stimulated. Encouragement of this discussion is in line with learning theories which indicate that concept clarification occurs during and as a result of the discussion.

Another emerging change in teaching style is the use by students of more opened investigative activities rather than traditional textbook type sets of questions. These activities are encouraged by LOGO, the 'supposer' software, statistics projects, graph investigations, and so on. This trend is regarded as a way of adding variety to mathematics teaching and as an initial step towards empowering students to take more control of their learning.

The final change affecting teachers is the emerging availability of software to assist in assessment recording (and scaling). This will no doubt be extended with software that handles other aspects of assessment.

4. *Software*

The Computer Division has developed three packages to support senior school mathematics and has purchased distribution rights for a graphing packages and a vector game for students at a lower level.

With the increasing availability of commercially produced software, the development of new software is now not so important although work with software with a Maori cultural and language bias is being considered.

An emerging task is the need for guidelines that help teachers use content-free packages such as word-processors, databases, and spreadsheets.

Another service that the Computer Division controls is a software

evaluation service. They designed an evaluation format, they organize software reviews and make these available with reviews from other countries through newsletters.

5. Teacher Support

Pre-service training institutions have staffing and provide opportunities for trainees to become familiar with computers. Courses are developing but at the moment emphasis enhanced teaching rather than the student-centred learning opportunities that computers allow.

In-service training with computers in all subjects including mathematics gets a fair share of in-service resources but these resources are limited and ideally would be extended.

Young high school mathematics teachers tend to have some computing qualifications and many older teachers learnt about computing when it was part of the applied mathematics course but both these groups emphasize programming while in-service courses stress the use of computers as aids to learning.

6. Other Issues

Three issues are emerging and need to be considered with respect to computing in general mathematics.

- The location of computers - while initially schools set up a computing room, there is now pressure to distribute machines so that one or two are available in classrooms where they will be used.

- The challenge of encouraging students to take more responsibility for their own learning - this fundamental change emphasizes encouraging learning the skills of learning and computing activities can facilitate this but it is somewhat threatening to many traditional teachers.

- The equity issues - these relate to gender, race, and class, and can be summarized as the issues to do with computer accessibility for all and software reflecting the interests and experiences of our diverse student population.

9: PAKISTAN

1. Introduction

The national system of education has three main stages: primary, secondary and higher. The primary section is from grades 1 to 5 while the secondary is from grade 6 to 10. The higher education system contains colleges (intermediate and degree) and universities. There are also commercial institutes and polytechnics which offer courses in about 21 different technologies after students have passed grade 10. There are four provinces in

the country and each has its own education department. The Federal Ministry of Education has policy formulating cum advisory role and gives financial support as needed. The Ministry is also responsible for the revision/modification of curricula working in close collaboration with the provincial curriculum centres.

2. *Computer Education*

Presently six universities, six public sector organizations and many private institutes own computers and provide computer certificates, diploma and degree courses of various duration. Almost all the universities are now being provided with main frame computers or micro-computers to start programmes in computer studies. The introduction of computers in schools has been slow due to the lack of trained people, financial constraints, inadequate repair and maintenance facilities, and lack of awareness of the potential of computers in education. However the situation is changing and the improvements that microcomputers can bring to the teaching-learning process have been recognized at various public and private forums. Two committees have been constituted by the Government to look into the possibilities of introducing microcomputers in schools and the utilization of the computer centres of universities and other organizations to enhance and start programmes in computer education.

The Ministry of Education and many other organizations have distributed computers to schools or provided funds to purchase computers under various motivational programmes. But due to the lack of trained teachers, technical know-how, software support, and other facilities; these are not being fully and effectively utilized. Some schools in the private sector have acquired computers through their own resources and are using them as teaching-learning aids.

3. *The Pilot Project*

The Science and Technology Wing of the Ministry of Education is launching a pilot project on the introduction of microcomputers to secondary schools. The main objective of the project is to establish a computer resource centre which would act as the nucleus of all activities including the training of teachers and the development of software and courseware. The project envisages the introduction of computers to 4 secondary schools in the first phase. Sixteen teachers (4 from each school) to cover Mathematics, Physics, Chemistry, Biology, Geography and English, will be trained in the centre through two workshops of two weeks duration each. The teachers will be trained in the use of software packages (word-processing, spreadsheet, database, LOGO). Eight computers will be installed in the centre for training of teachers, software development and replacement purposes.

After the training of teachers, the project schools will be provided with computers (8 each) and computer rooms will be set up in each school. Two periods (80 minutes) per week for each subject (Maths, Physics, Chemistry, Biology, Geography, English) will be allocated in the school timetable for work with computers. The students will work in groups, 3 to 5 students per computer, under the guidance and supervision of their teachers. Initially the

available software packages will be used. At the same time the programmers and professionals employed in the centre will work in collaboration with teachers to change existing software and develop new software in line with the school syllabus. It is expected that extension of this project would lead to the establishment of more resource centres in other parts of the country.

4. *Curriculum Development and Teachers Training*

An Institute for the Promotion of Science Education and Training (IPSET) is being established with a network of four regional centres, one in each province. The major programmes of the institute include reviewing the existing science curricula, textbooks, teachers' guides and experimental activities and conducting in-service training for teachers of grades 6 to 12. The institute will have an instructional services unit with a computer laboratory that will be responsible for the development of science and computer education.

As a first step towards launching computer education activities, a guide book on the introduction of microcomputers in education has recently been published. It is addressed to educational administrators and planners, school and college teachers, students and the general public. It is hoped that the teachers will find it useful and informative.

There are 71 teacher training institutes for the primary and middle level teachers, 12 training colleges for the secondary school teachers and 5 university institutes of education and research (IER) in the country. At present no courses relating to the use of computers in the classroom are taught in these institutes. A small but active computer cell in the National Education Council, Islamabad is training small groups of in-service teachers and students.

5. *Mathematics Curriculum*

The use of microcomputers in schools entails changes in the curriculum. Mathematics education is one area where the much use can be made of the computer. Due to the limited number of schools using computers in mathematics teaching, the mathematics syllabus may not be revised, but computers can be introduced in schools as an aid to teaching and learning with the existing syllabus.

Possible topics for the primary level that can be enhanced through the use of computers include operations on numbers, simple geometry, graph and tables, measurements of distance and time, and problem solving.

Possible topics for the secondary level are: simplification of algebraic expressions involving brackets, arithmetic skills, ratio, proportions, and percentages, commercial mathematics, geometry and proof of theorems, graphs and tables, areas and volumes, and trigonometry.

6. Future Programmes

Some of the future moves to speed up computer usage in education are as follows:

1. To organize workshops on the use of computers in education;

2. To conduct courses on computer education in all universities and engineering colleges;

3. To strengthen the polytechnics of the country as potential resource centres;

4. To establish independent resource centres for students to study computers outside school hours;

5. To provide incentives to the local industries for the development of local hardware and software; and

6. To improve the existing computer training facilities in the public sector organizations.

10: PHILIPPINES

1. Introduction

The almost universal availability and use of computers can and has begun to, affect schools. Some public and private secondary schools offer computer courses where students get direct experience in hands-on computing. The subject, often offered as an elective in the fourth year of Mathematics and usually called 'Introduction to Computers', deals with understanding a computer system, problem solving algorithms, making flow charts, BASIC programming, and writing and running simple programmes. In some secondary schools this is offered instead of practical arts.

The Department of Education, Culture and Sports (DECS) through the Bureau of Secondary Education (BSE) has suggested some guidelines.

1) Schools may purchase their own microcomputers but the cost should not be borne by students or taken form tuition fees;

2) Computer education may be offered from the first to the fourth year of secondary education;

3) The content of computer education may form part of the instruction in areas such as mathematics, science, communication arts and practical arts;

4) Computer education may be offered as an elective;

5) A tie-up with local businesses that utilize microcomputers may be made by the school to provide hands-on learning; and

6) There should be a teacher trained in computing to handle the subject.

One study on computer education showed that the capabilities of computers in the teaching and learning of mathematics have not yet been explored. The computer is not used to explore mathematical ideas, for problem solving, for simulation and for drill. Programming is taught with the main object of enabling students to learn programming.

The slow introduction of computers in the secondary school system could be attributed to a combination of the following factors: lack of hardware and software, untrained teachers and inadequate support services.

2. *Curriculum Development*

The DECS through the BSE is currently trialling secondary education curriculum. To be implemented in June 1989, the proposed curriculum was prepared to accommodate better quality inputs into the secondary school system. Aside from the addition of two new subjects (Work Experience and Values Education), the proposed curriculum is competency-based, and technology and values oriented.

The mathematics programme of the 1989 curriculum includes key concepts in algebra, geometry, consumer mathematics and statistics, spirally organized at every year level. The content is envisioned to be that which every citizen must have as their basic mathematical knowledge and skills, and is defined in terms of competencies expected of Filipino secondary school students/graduates.

Because of the increasing effects and uses of calculators and computers, competencies related to these tools were included. The competencies across the four curriculum years include: use a calculator (while maintaining computational skills) to perform a series of operations, to expedite computation in problem solving and to evaluate numerical expressions; make and interpret simple flow charts to show problem solving procedures and carry out the problem solving procedure presented in a flow chart; describe a computer, its parts and functions, write programmes in BASIC and run simple computer programmes; and operate a programmable calculator and/or a personal computer.

The advent of computers has affected the content of the mathematics programme. New topics will be introduced while some topics will be deleted or de-emphasized.

Flow charting and programming are to be enhanced. These topics help the students in problem solving. Statistics and probability could also be enhanced as the computer can provide simulations and display data in the form of charts and graphs. Through simulations, the computer can present to the student situations or problems as they occur in the real world.

With computers, certain topics will require a different approach in teaching. With LOGO and graphics, a more intuitive approach in the teaching of geometry can be used and computers will intensify the development of

geometry concepts.

A change in the emphasis and sequencing of topics will take place. With calculators and computers the decimal system of numeration is used so the teaching of fractions and decimals will need to be done simultaneously. Computations involving fractions will be de-emphasized while those involving decimals will be emphasized more. Consequently, the content of mathematics will undergo continuous review to accommodate the new topics and the development of new teaching models.

3. *Software Development and Review*

The University of the Philippines Institute for Science and Mathematics Education Development (UPISMED) has included software development for science and mathematics education as an expansion of its curriculum development function. To spearhead this endeavor a microcomputing workgroup was organized and has also assumed the additional task of evaluating software purchased. The workgroup has developed software which comes with a module which would enable a student to work independently. The developed software have been evaluated by the school teachers undergoing the short courses conducted by the institute.

4. *Teacher Support and Development*

Computer education has not been formalized as a part of the curriculum in teacher training. There are a number of agencies and institutions that conduct computer training sessions through seminars and workshops for teachers. The training comes at many levels and includes appreciation and familiarization courses, use of application software and programming concepts. These institutions consider it as a part of their extension services and offer the programmes at no cost or at a minimal cost.

5. *Issues*

Computer education will find a place in the secondary school system. At present, there is a need to define the direction of computer education. Some issues for consideration include:

1) the nature of computer education in secondary schools;

2) the development and implementation of a secondary schools computer education plan;

3) the training of teachers (pre- and in-service); and

4) the establishment of a mechanism for software development and review.

Some of these may be resolved through pilot programmes then gradually expanded as resources allow, but the others need further study.

11: REPUBLIC OF KOREA

1. *Introduction*

To help us function effectively in a society that relies more on computers, the need for a knowledge of computers is emerging. In Korea, the need for computers was first voiced in the late sixties by the Korea Institute of Science and Technology and by the Statistics Bureau of the Economic Planning Board. As these systems were developed the importance of computer education emerged and was first attempted in commercial high schools by the new curriculum proclaimed in 1971.

Currently aspects of computers are taught in three areas:

(1) In general high schools, the topics related to computers are included in industrial arts and the aim is to provide a basic understanding about the computer.

(2) In technical high schools, the structure of computers is a compulsory topic while computer programming and microcomputers system programming are electives.

(3) In commercial high schools, computer calculations, general programming, Fortran, Cobol, and Assembler language are all possible major study areas. Other courses such as commerce, accounting, and international trade can study these areas.

Elementary, middle and high school have not yet introduced subjects related to the computer into the regular classroom but some schools have computer education as 'a special activity'.

2. *Mathematics Curriculum Development*

The new mathematics curriculum was strongly influenced by what other countries had suggested together with the demands of our society and mathematics educators' suggestions.

Every year the Ministry of Education and educational research institutes evaluate the mathematics curriculum in terms of:

1) sequence of contents,
2) level of understanding of each concept,
3) new topics that should be introduced in the future,
4) present topics that should be deleted, and
5) social needs and current issues in the world.

Currently, the curriculum designers are trying to keep a moderate 'new mathematics movement', enhance problem solving, emphasize the basics, and introduce computer activities into the mathematics classroom.

3. Learning and Teaching

Learning and teaching was a major research area in Korea and individualized instruction, discovery learning, and other model were considered.

4. Software Development

Some educational software related to mathematics was developed but it is not satisfactory in terms of creativity and variety. The need and demand for suitable educational software is increasing, so the educational research center under the Ministry of Education is actively involved developing software in the following three areas:

* concept learning (e.g. discovery learning);
* problem solving; and
* skills.

5. Teachers Support and Development

A recent survey of teacher support reveals that the average number of teachers teaching computer courses in schools is 2 or 3 and many teachers have qualifications in other subject areas (Commerce, Electricity, Mathematics, etc.). They have also received training supported by the Local School Board in cooperation with the computer science faculties of the universities.

A recent survey shows that over 43 colleges are offering degree courses in computer science and these will provide many qualified teachers, so the prospect is good in terms of teacher supply.

6. Other Issues

Beside the issues listed above, mathematics teachers are expected to be involved in discussion with computer educators in terms of the following questions:

1) In which subjects is it appropriate to introduce the computer?

2) Who should teach the computer courses?

3) What is the future role of computer in education in our country?

12: SRI LANKA

1. Introduction

The increasing use of computers in Sri Lanka made it necessary for the Ministry of Education to initiate programmes within the school system so that students leaving school have an awareness of the possibilities of this new technology.

Under its Microelectronic Education Programme, the Ministry of Education started 'Computer Awareness' courses at the GCE (Advanced Level) classes in about a hundred schools.

Six microcomputer training centres were established in selected schools in order to train teachers. At these centres some mathematical software is used.

By 1987 the Microelectronic Education Programme will have been expanded so that microcomputers are used in two hundred schools.

2. *Curriculum Development*

The microcomputer education programme was introduced on a pilot basis in 1982. The students in GCE (Advanced Level) first year classes follow a computer programming course taking three periods per week. This course is to be available in all secondary schools in the near future.

In the six selected schools microcomputers are used in a wide range of activities including solving mathematical problems. All the usual operations with numbers are used by students writing programmes. The software that students produce covers 'solving quadratic equations', 'adding and subtracting matrices', 'mathematical tables', and 'Newton approximation to find the roots of an equation'. Languages such as LOGO which have been designed for children to develop understanding in mathematical concepts and logic have also been used.

3. *Learning and Teaching*

Computers programming starting with flow-charts is done to show the steps that a computer takes in solving a problem and to give a logical outline and reinforcement of the procedures followed in mathematics for the problem. These programmes, developed by students at the selected schools are saved on diskettes.

4. *Software Development*

Microcomputers are used in computer literacy classes and software covering a number of aspects of mathematics is developed by the students. This software includes: roots of quadratic equations; roots of polynomial equation (using Newton's approximation); limits of functions; sums of series; convergency of series at a limit; permutations and combinations; the binomial theorem; conics; graphing trigonometric functions; curves with maximums and minimums and graphs of these functions; graphs of curves from polar equations such as $\iota /r = 1 + e \cos \theta$; numerical integration (using Newton's approximation, Trapezoidal rule, and Simpson's rule); applications of Taylor's expansion and Maclaurin's theorem; and collection of data in statistics.

5. Teacher Support and Development

An awareness of current developments is important for mathematics teachers so that their teaching is as effective as possible, therefore refresher courses are needed for mathematics teachers involved in teaching computer awareness. Such courses will involve a sharing of experiences which will be useful to participants.

It will also be necessary to build up a small team of teachers in each school with training in computer awareness so that it can be taught effectively.

6. Other Issues

There are now six computer training centres in Sri Lanka, steps have been taken to set up two more and ideally four more will be set up. These will provide support for teachers of all subjects including mathematics teachers as they were set up to train teachers and to provide opportunities for interested students to enhance their computer skills.

Other places where computer education could take place are at teachers colleges and at field study and science education support centres.

13: THAILAND

1. Introduction

The low price of microcomputers in Thailand has opened new possibilities for computer education in schools. In 1982, many upper secondary schools had computers. At that time the schools allowed students to study computing as a computer club activity. Realizing the importance of the new technology, the Institute for the Promotion of Teaching Science and Technology (IPST) was asked by the Ministry of Education to develop a computing curriculum. Two computer courses - Introduction to Computer Concepts, and BASIC Programming - have been provided for upper secondary schools as elective courses within Mathematics. These have been tried out in three school in Bangkok, in 1984. In 1985, the Ministry of Education implemented the two courses throughout the country.

The objectives of the courses are to develop:

(1) basic understanding of computer systems;

(2) perceptions of appropriate work for computers;

(3) the ability to apply problem-solving algorithms computers;

(4) a knowledge of programming and the ability to write simple programmes;

(5) the ability to run a simple computer programme; and

(6) logical thinking, systematic thinking, carefulness and creativity.

The course descriptions of these two courses are:

Introduction to Computer Concepts - computer awareness, organization of a computer system, data processing, languages, computers for today and tomorrow.

BASIC programming - introduction, system commands and programme statements, components of the BASIC language, some BASIC commands, some algebraic functions, subscript, dimension, string function, manipulation of programmes in BASIC.

2. *Mathematics Curriculum Development*

Before 1977, the existing nationwide mathematics curriculum of Thailand was very traditional. Emphasis was on skills in arithmetical computation, algebra, and Euclidean geometry with little attention to concepts and structure. The IPST, being responsible for mathematics curriculum, started to examine the existing mathematics curriculum and to seek appropriate changes. In 1973, IPST organized conferences attended by mathematicians, mathematics educators, curriculum specialists and evaluators from the universities, colleges of education, supervisory units and schools to brainstorm on the general directions most suitable for Thailand's own situation. As the result of these conferences and in combination with surveys and other research, the mathematics team of IPST worked out the entire twelve grades' mathematics curriculum.

A plan was devised to revise the mathematics curriculum, try out the revision and then implement it throughout the country. IPST chose to start working on many levels at the same time in order to shorten the time of revision for all twelve grades. The schedule for revision, testing and implementation for the curriculum for each grade started in 1974 and was planned to be completed by 1989.

3. *Learning and Teaching Models*

A spiral approach was adopted for all 12 years of the programme. The topics taught in previous levels are reviewed and more is added to give more depth. A hierarchy of concepts was used as a guideline for this approach.

Teaching for understanding is emphasized with the conviction that understanding leads to skill. For young children understanding is developed through activities and experiences. Teaching aids are encouraged in class. For older students reasoning abilities are expected. Though concepts are regarded as important developing computational skills are not neglected. A balance between concept and skill development is the goal.

Guided discovery is encouraged through activities supported by student-teacher dialogues and discovery-type problems formulated with regard to the principles of child development.

Building on students' interests and developing positive attitudes toward mathematics is a desired outcome. Providing students with experiences to see the applications of mathematics and linking these with the students' environment to develop meaningfully concepts are the strategies used to promote such attitudes and interests.

4. Software Review and Development

Microcomputers have been put in Thai school to use in three areas:

Firstly, administration, about one hundred upper secondary schools have computers to use to keep school records, such as student records, school accounts, to process examination marking, etc.

Secondary, computer studies, about sixty schools have provided computer courses.

The last area is computer assisted learning. However as yet they are rarely used in this area.

IPST has realized the importance of computers and in 1986, IPST organized a conference about using computers to aid teaching and learning. The objective of the conference is to see and exchange computer programmes to aid teaching and learning. In April 1987, IPST organized another training workshop about using the computer to aid mathematics and physics learning. The objective of the workshop is to consider which mathematics and physics topics should be enhanced and to write storyboards of some topics as the preliminary stage of software development.

5. Teacher Support and Development

The IPST, being responsible for computer curriculum, conducted the In-Service Training Programme for teachers who have to teach the computer courses in April/May 1985. In 1986, the institute organized a workshop for the key people from universities and teacher colleges to learn about the computer curriculum so that these universities and teacher colleges can conduct in-service training for teachers.

Appendix 3: List of Some Computing Terms

Algorithm: A complete description, usually in an order, of a process which is used to provide required information.

Application Software: Software which uses principles, knowledge or skills previously gained in an unfamiliar situation.

Authoring system: Usually software which enables speedy creation of computer based lessons and tutorials for students.

Backup Availability: Software and data is usually transported on disks, a magnetic medium. Because these have occasional failures, extra copies, called backups, should be available to minimize any inconvenience when these failures occur.

Code: Code may be either; a programme, or section of a programme, written in a programming language, or; the process of transforming an algorithm into a set of instructions understandable by computers.

Database: Either the means of organizing data (or information) to produce specific reports in answer to questions (such as a list of students with marks greater than 50), or the actual data itself. In general, the term has come to mean computers based data.

Hardware: In common use, this term refers to the physical collection of equipment associated with and including a computer, such as screens (or visual display units), keyboards, disk drives, etc. (See software)

Investigatory Software: Software which allows its user choice and possibilities for investigation, without restriction to a number of predetermined options.

LOGO: A programming language based on procedures and the use of 'turtle graphics', which lends itself particularly well to investigation and is part of the class of open ended software.

Modelling: A means by which physical or other processes and events may be mathematically simulated, through the use of mathematical systems, or computer software.

Open Ended Software: Software which does not restrict the user to any particular approach or content.

Programming Languages: A programming language is the means of conveying instruction sequences and some data to a computer. Examples of commonly used languages include: BASIC, Pascal, Prolog, LOGO, FORTRAN, and COBOL.

Software: A general term used to encompass programmes, (which instruct machines in the processes required) and data, which is then processed. It is related to hardware because both hardware and software are needed for computer use.

Spreadsheet: A type of computer software, which enables users to create and modify large grid structures, containing numerical data and the formulae and labels describing them (such as columns of values and their sums and averages). The power of this software lies partly in the ability of it to recalculate results after changes or modifications have been made to the source data.

Tutorial Software: Software that approximates and enriches the classroom learning environment of interaction between teacher and student.